Table 1. Effects of composition on physical properties of SPI[1]/PVA[2]/PVP[3] foam sheets[4]

Sample	PVA/PVP (Parts)	Density (g/cc)	Tensile strength (MPa)[5]	Elongation (at break, %)[5]	Young's modulus (MPa)[5]
1	0/0	0.53	6.47 ± 0.56	7.67 ± 1.61	164.90 ± 49.60
2	2/0	0.61	4.70 ± 0.37	23.39 ± 5.09	125.30 ± 33.33
3	3/0	0.47	5.72 ± 0.55	28.13 ± 12.05	153.00 ± 33.43
4	2/2	0.47	7.61 ± 0.64	8.48 ± 0.82	178.70 ± 25.40
5	10/3	0.52	6.95 ± 0.75	15.22 ± 3.46	161.00 ± 24.20

[1]SPI: soy protein isolate
[2]PVA: poly(vinyl alcohol)
[3]PVP: Poly(vinyl pyrrolidone)
[4]Formulation: 100 parts SPI, 80 parts water, 25 parts glycerol, and 1 part sodium tripolyphosphate, (all based on 100 parts dry weight soy protein).
[5]Mean ± standard deviation.

FIG. 1

Table 2. Effects of PVA concentration on physical properties of SPI[1]/PVA[2]/PVP[3] foam sheets[4]

Sample	PVA/PVP	Density (g/cc)	Tensile strength (MPa)[5]	Elongation (at break, %)[5]	Young's modulus (MPa)[5]
1	0	0.45	4.96 ± 0.88	3.69 ± 0.75	205.7 ± 38.2
2	10/2	0.54	6.40 ± 0.68	4.2 ± 0.56	243.6 ± 38.7
3	20/2	0.56	7.54 ± 0.82	9.17 ± 2.86	257.7 ± 51.10
4	30/2	0.52	7.65 ± 0.68	6.72 ± 1.55	266.4 ± 27.4
5	40/2	0.53	8.04 ± 0.48	11.61 ± 3.80	281.1 ± 27.9

[1]SPI: soy protein isolate
[2]PVA: poly(vinyl alcohol)
[3]PVP: Poly(vinyl pyrrolidone)
[4]Formulation: 100 parts SPI, 80 parts water, 20 parts glycerol, 0.5 parts potassium sorbate (preservative), and 1 part sodium tripolyphosphate, (all based on 100 parts dry weight soy protein).
[5]Mean ± standard deviation.

FIG. 2

Table 3. Effects of octenyldecene succinic anhydride on physical properties of SPI[1]/PVA[2]/PVP[3] foam sheets[4]

Sample	PVA/PVP	ODSA[5]	Density (g/cc)	Tensile strength (MPa)[6]	Elongation (at break, %)[6]	Young's modulus (MPa)[6]
1	0	0	0.50	6.30 ± 4.02	4.02 ± 0.61	193.7 ± 25.4
2	10/2	2	0.51	6.21 ± 0.61	5.28 ± 0.35	141.2 ± 35.5
3	20/2	2	0.55	6.52 ± 0.51	12.93 ± 3.09	190.5 ± 52.40
4	30/2	2	0.52	6.61 ± 0.40	14.15 ± 3.10	151.0 ± 20.4
5	40/2	2	0.45	6.43 ± 0.53	11.39 ± 2.68	170.10 ± 34.57

[1]SPI: soy protein isolate
[2]PVA: poly(vinyl alcohol)
[3]PVP: Poly(vinyl pyrrolidone)
[4]Formulation: 100 parts SPI, 80 parts water, 20 parts glycerol, 0.5 parts potassium sorbate (preservative), and 1 part sodium tripolyphosphate, (all based on 100 parts dry weight soy protein).
[5]ODSA: octenyldecene succinic anhydride
[6]Mean ± standard deviation.

FIG. 3

Table 4. Effects of glycerol concentration on physical properties of SPI[1]/PVA[2]/PVP[3] foam sheets[4]

Glycerol (parts)	PVA/PVP	Density (g/cc)	Tensile strength (MPa)	Elongation (at break %)	Young's modulus (MPa)
Blank	0/0	0.46	5.86 ± 0.38	11.54 ± 2.41	158.8 ± 39.6
20	10/3	0.44	6.57 ± 0.55	16.33 ± 0.60	162.7 ± 33.4
25	10/3	0.47	4.89 ± 0.33	37.75 ± 5.08	125.2 ± 26.6
30	10/3	0.47	3.96 ± 0.24	65.52 ± 2.42	90.62 ± 15.12

[1]SPI: soy protein isolate
[2]PVA: poly(vinyl alcohol)
[3]PVP: Poly(vinyl pyrrolidone)
[4]Formulation: 100 parts SPI, 80 parts water, 1 part sodium tripolyphosphate, (all based on 100 parts dry weight soy protein). Blanks contains 20 parts glycerol.
[5]Mean ± standard deviation.

FIG. 4

Table 5. Effect of gelatin on the physical properties of SPI[1]/PVA[2]/PVP[3] foam sheets[4]

Sample	PVA/PVP (parts)	Gelatin (parts)	Density (g/cc)	Tensile strength (MPa)	Elongation (%)	Young's modulus (MPa)
1	0	0	0.46	5.86 ± 0.38	11.54 ± 2.41	158.8 ± 39.6
2	10/3	0	0.44	6.57 ± 0.55	16.33 ± 0.60	162.7 ± 33.4
3	10/3	6	0.43	7.11 ± 0.48	14.42 ± 1.48	170.8 ± 37.8
4	10/3	10	0.52	7.47 ± 0.30	18.81 ± 6.06	162.5 ± 16.2

[1]SPI: soy protein isolate
[2]PVA: poly(vinyl alcohol)
[3]PVP: Poly(vinyl pyrrolidone)
[4]Formulation: 100 parts SPI, 80 parts water, 20 parts glycerol, 0.5 parts potassium sorbate (preservative), and 1 part sodium tripolyphosphate, (all based on 100 parts dry weight soy protein).
[5]Mean ± standard deviation.

FIG. 5

Table 6. Effect of processing aides on physical properties of SPI[1]/PVA[2]/PVP[3] foam sheets[4]

Sampl (0.5 parts)	PVA/PVP	Density (g/cc)	Tensile strength (MPa)	Elongation (at break, %)	Young's modulus (MPa)
Blank	0	0.44	2.96 ± 0.20	42.20 ± 5.84	56.37 ± 8.65
NaCl[6]	2/1	0.49	3.63 ± 0.32	52.48 ± 12.76	91.84 ± 17.62
Na_2SO_3[6]	2/1	0.51	3.50 ± 0.36	60.88 ± 6.25	76.18 ± 11.37
CaSt[6]	2/1	0.63	3.88± 0.28	56.80 ± 9.58	86.77 ± 35.12
ZnSt[6]	2/1	0.59	3.35 ± 0.07	48.59 ± 7.81	68.11 ± 9.32
SDS[6]	2/1	0.53	3.57 ± 0.34	62.00 ± 7.88	104.60 ± 26.54
Uniflex[6]	2/1	0.60	3.06 ± 0.16	50.22 ± 2.99	73.49 ± 23.88
Int-38H[6]	2/1	0.56	3.24 ± 0.40	50.42 ± 8.22	85.43 ± 25.50
Int66HS[6]	2/1	0.61	3.95 ± 0.27	57.64 ± 6.79	88.11 ± 15.80

[1]SPI: soy protein isolate
[2]PVA: poly(vinyl alcohol)
[3]PVP: Poly(vinyl pyrrolidone)
[4]Formulation: 100 parts SPI, 80 parts water, 20 parts glycerol, 0.5 parts potassium sorbate (preservative) and 1 part sodium tripolyphosphate, (all based on 100 parts dry weight soy protein).
[5]Mean ± standard deviation.
[6]NaCl= sodium chloride, Na_2SO_3= sodium sulfite, CaSt= calcium stearate, ZnSt= Zinc stearate, SDS= sodium dodecyl sulfate, Uniflex= commercial lubricant from Union Camp company, Int-38H= internal lubricant from Axel company, Int-66HS= internal lubricant from Axel company

FIG. 6

Table 7. Effects of flavoring agents on physical properties of SPI[1]/PVA[2]/PVP[3] foam sheets[4]

Sample	Flavoring agent	PVA/PVP	Density (g/cc)	Tensile strength (MPa)	Elongation (at break %)	Young's modulus (MPa)
1	0	3/2	0.42	5.45 ± 0.80	10.54 ± 2.47	172.40 ± 31.6
2	0	3/2	0.47	5.72 ± 0.55	28.13 ± 12.05	153.00 ± 33.43
3	Lemon	3/2	0.39	4.92 ± 0.83	10.97 ± 1.39	136.10 ± 19.63
4	Almond	3/2	0.38	5.18 ± 0.95	13.31 ± 1.90	137.20 ± 24.81

[1]SPI: soy protein isolate
[2]PVA: poly(vinyl alcohol)
[3]PVP: Poly(vinyl pyrrolidone)
[4]Formulation: 100 parts SPI, 80 parts water, 20 parts, 0.5 parts potassium sorbate (preservative), and 1 part sodium tripolyphosphate, (all based on 100 parts dry weight soy protein).
[5]Mean ± standard deviation.
Lemon and Almond flavoring agents= 1 part each

FIG. 7

Table 8. Effects of colorants on physical properties of SPI[1]/PVA[2]/PVP[3] foam sheets[4]

Sample	colorant	PVA/PVP	Density (g/cc)	Tensile strength (MPa)[5]	Elongation (at break, %)[5]	Young's m (MPa
1	0	0/0	0.42	5.45 ± 0.80	10.54 ± 2.47	172.40 ±
2	0	3/2	0.47	5.72 ± 0.55	28.13 ± 12.05	153.00 ±
3	Phthalocyanine[6]	3/2	0.59	4.30 ± 0.45	20.84 ± 5.0	111.30 ±
4	Phthalocyanine green[7]	3/2	0.59	4.47 ± 0.33	23.06 ± 12.37	128.80 ±

[1]SPI: soy protein isolate
[2]PVA: poly(vinyl alcohol)
[3]PVP: Poly(vinyl pyrrolidone)
[4]Formulation: 100 parts SPI, 80 parts water, 20 parts glycerol, 0.5 parts potassium sorbate (preservative), and 1 part sodium tripolyphosphate, (all based on 100 parts dry weight soy protein).
[5]Mean ± standard deviation.
[6]Phthlocyanine (blue/green) = 0.05 parts
[7]Phthalocyanine green (green)= 0.05 parts

FIG. 8

FIG. 9

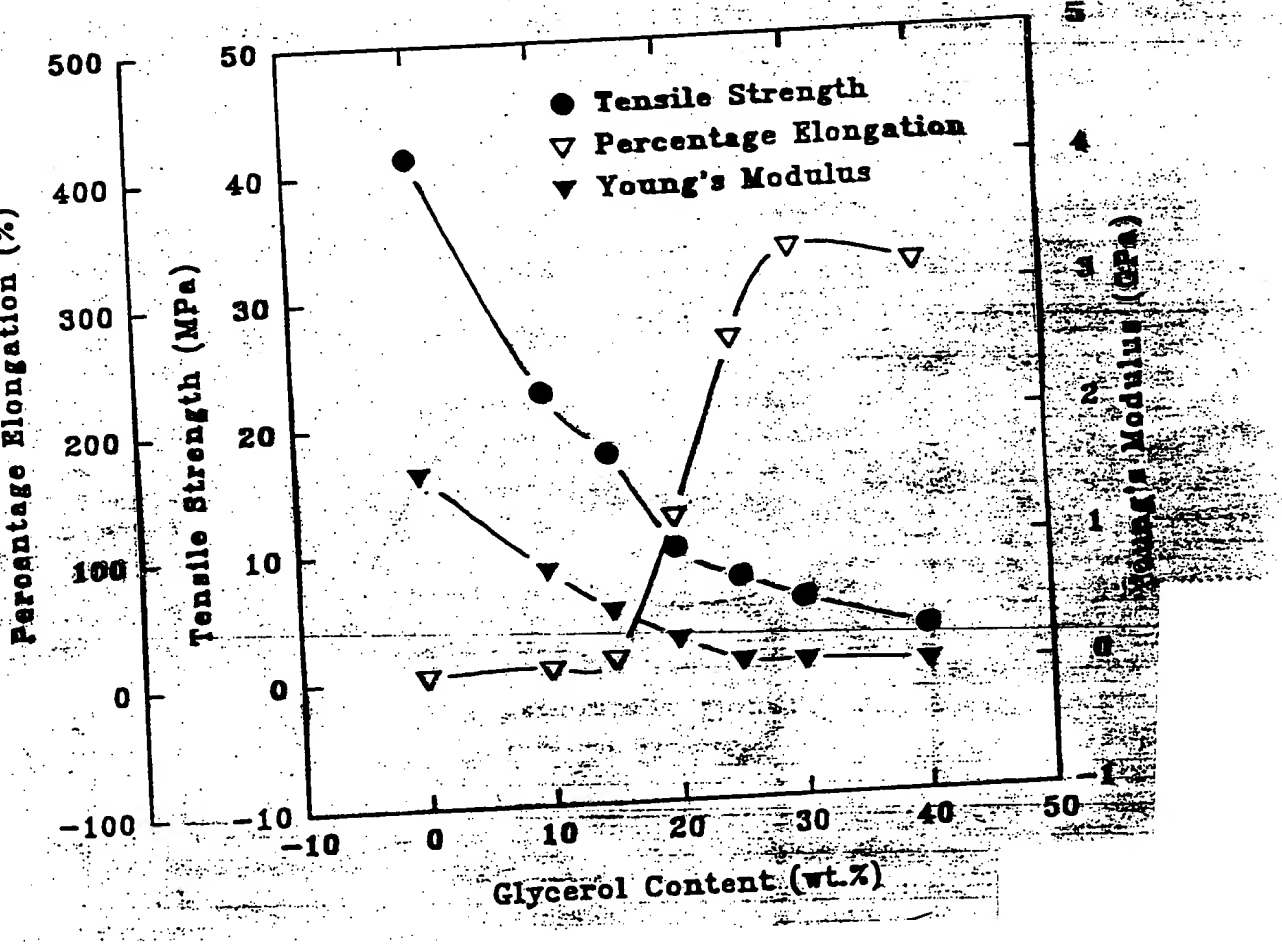

Tensile Strength
Percentage Elongation
Young's Modulus
Percentage Elongation (%)
Tensile Strength (MPa)
Young's Modulus (GPa)
Glycerol Content (wt.%)
500
400
300
200
100
0
50
40
30
20
10
0
-10
5
4
3
2
1
0
-1
-100
-10
0
10
20
30
40
50

FIG. 10

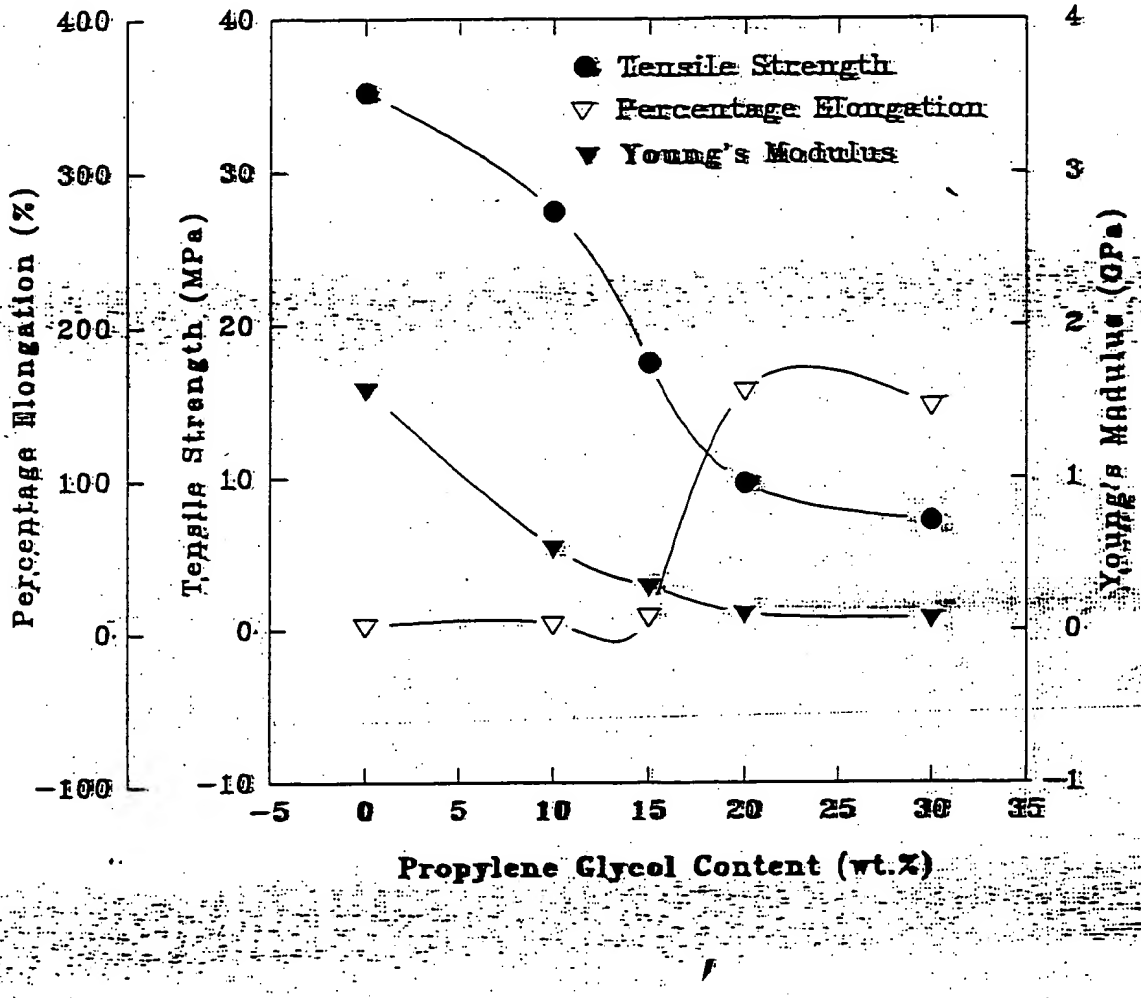

Tensile Strength
Percentage Elongation
Young's Modulus
Percentage Elongation (%)
Tensile Strength (MPa)
Young's Modulus (GPa)
Propylene Glycol Content (wt.%)
400
300
200
100
0
-100
40
30
20
10
0
-10
4
3
2
1
0
-1
-5
0
5
10
15
20
25
30
35

FIG. 11

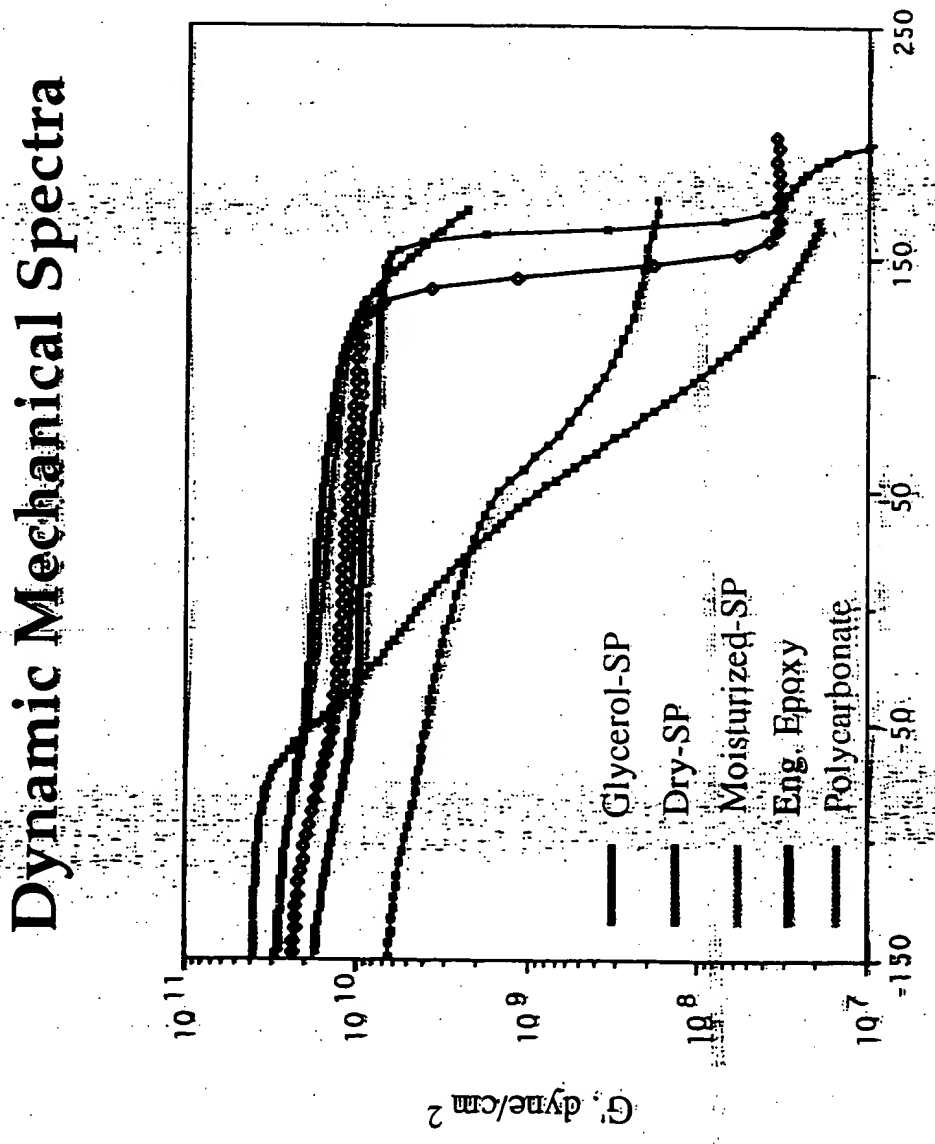
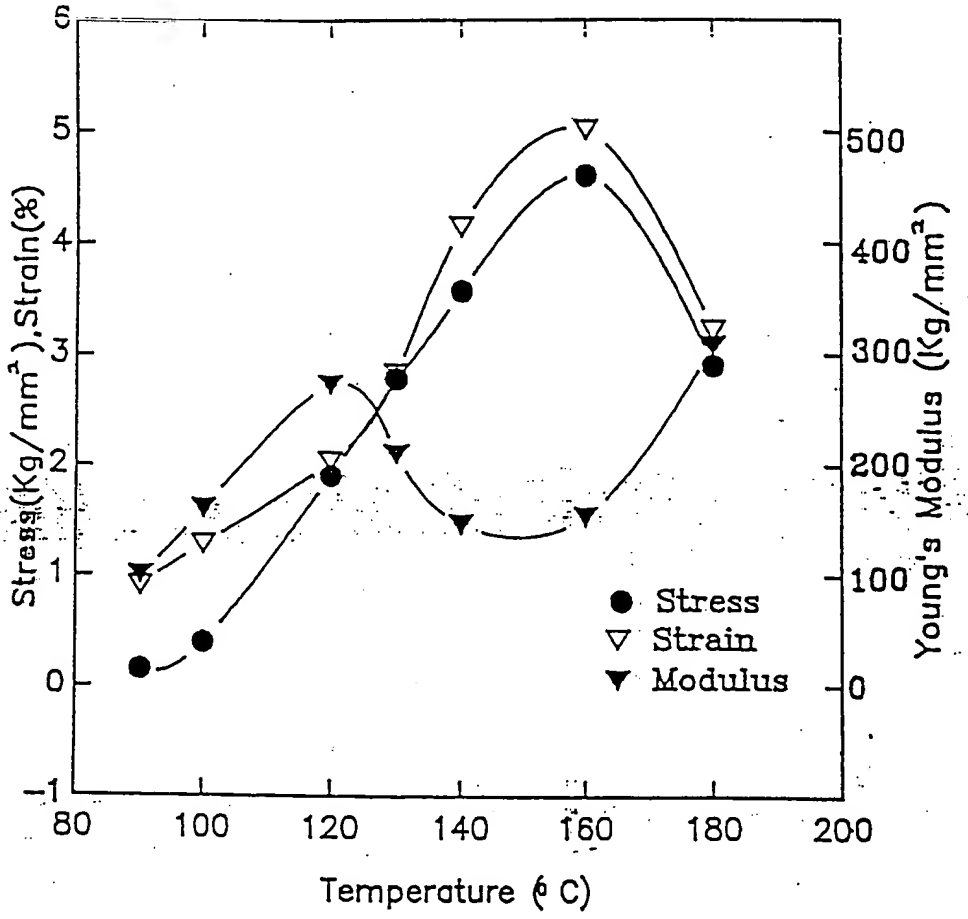

Dynamic Mechanical Spectra
G', dyne/cm 2
10 11
10 10
10 9
10 8
10 7
-150
-50
50
150
250
Temperature, °C
Glycerol-SP
Dry-SP
Moisturized-SP
Eng. Epoxy
Polycarbonate

FIG. 12



Effect of Molding Temperature on Mechanical Properties of Compression-Molded Soy Protein Plastics.

FIG. 13A

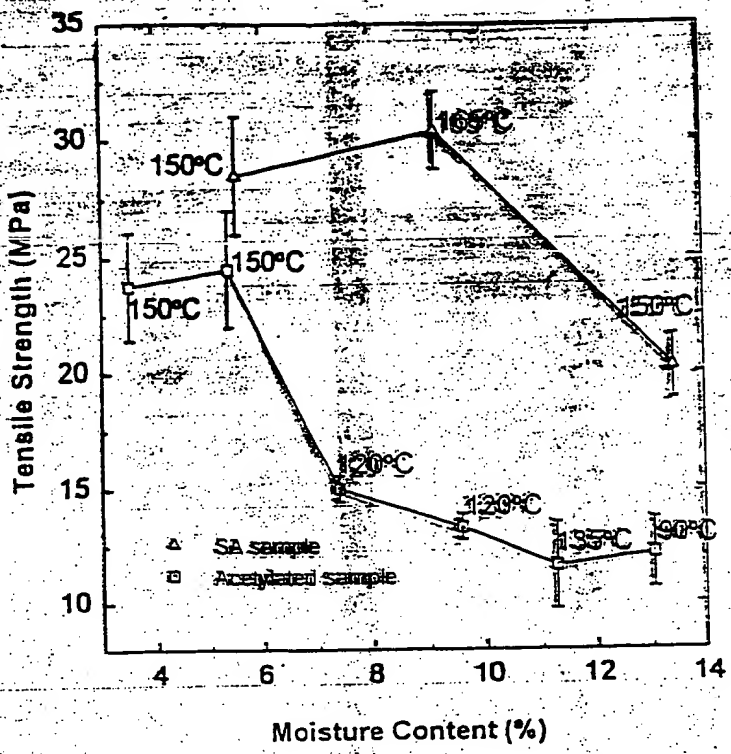


FIG. 13B

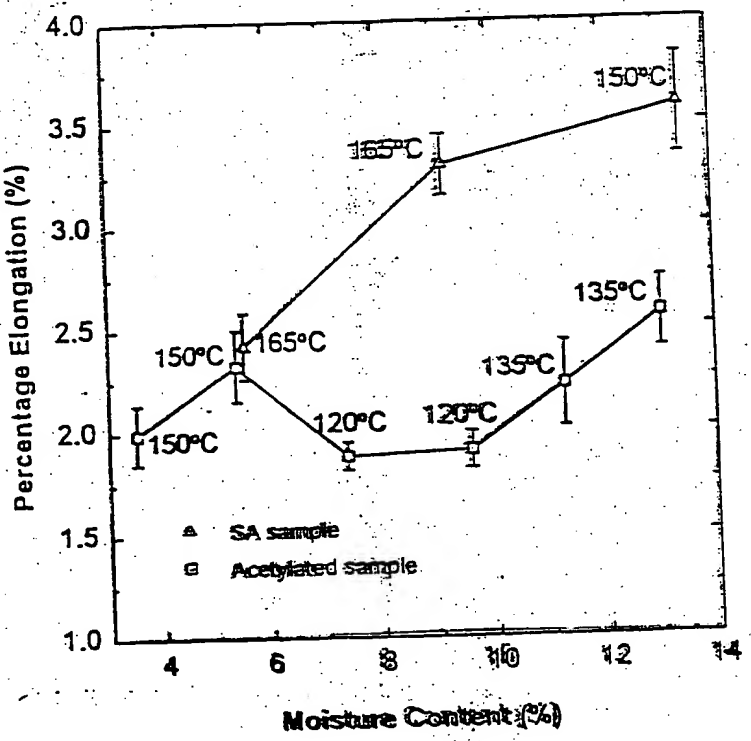
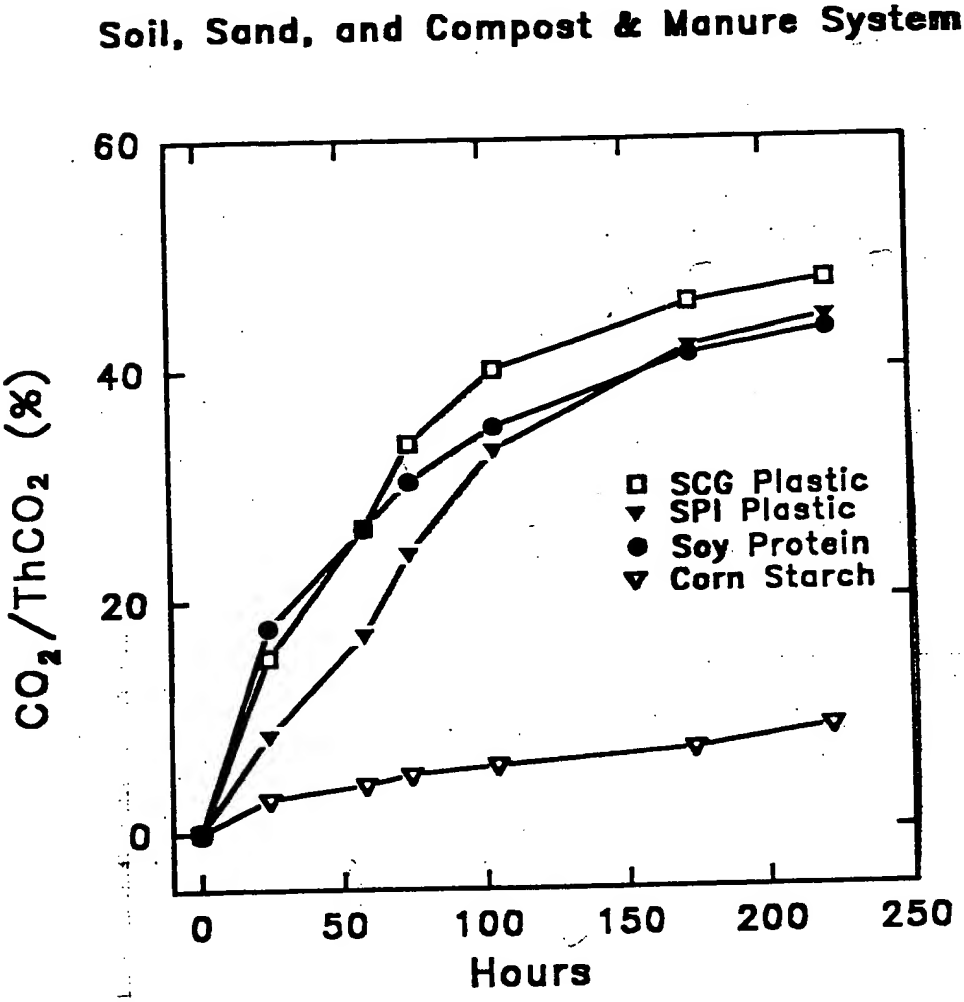


Figure 2. Maximum mechanical properties obtained for specimens made from acetylated soy protein and from sodium acetate-treated soy protein (SA sample, control) at indicated optimal molding temperature.

FIG. 14


Soil, Sand, and Compost & Manure System
60
40
20
0
$CO_2/ThCO_2$ (%)
0
50
100
150
200
250
Hours
SCG Plastic
SPI Plastic
Soy Protein
Corn Starch